

HEP Superconducting Magnet R&D

ILC Beam Delivery System

LARP - Magnet

Superconducting Materials

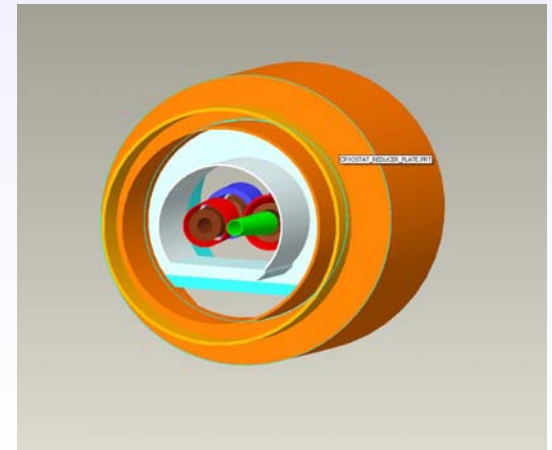
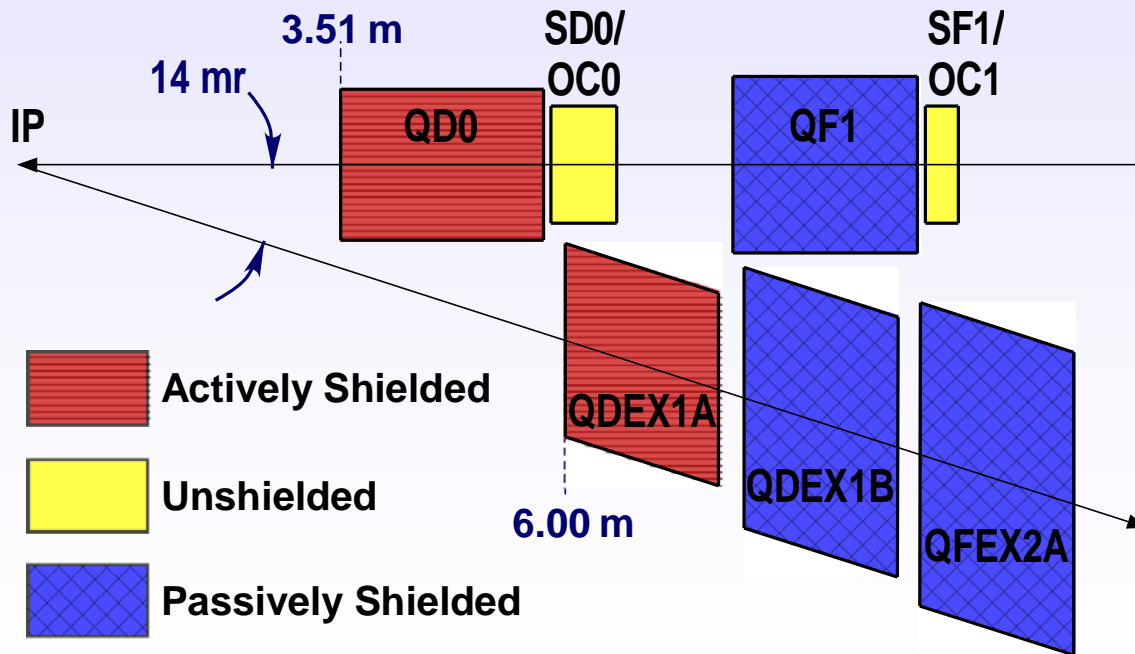
High Field Magnet

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ILC Beam Delivery System (BDS) R&D

Overview: ILC has selected a 14 mrad BDS, using superconducting magnets. Conceptual design for 14 mrad (magnets, optics) worked out at BNL.

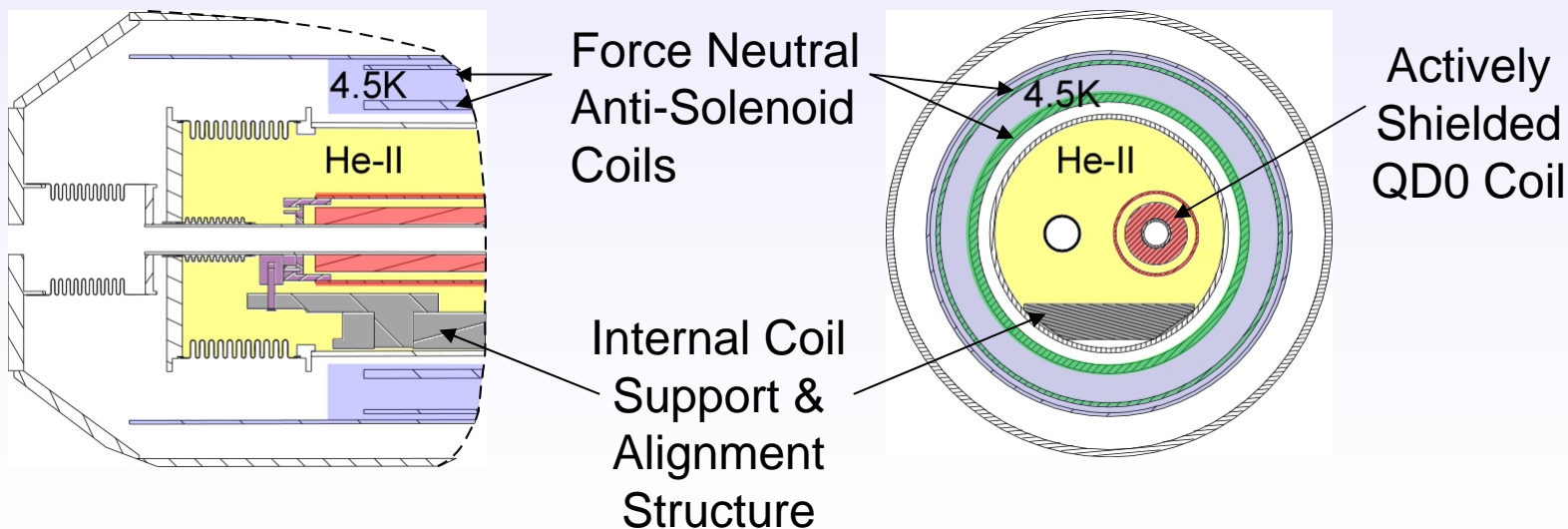
BNL Scope: Magnets, magnet vibration, cryostats, interface to push-pull arrangement of experiments, antisolenoids for experiments.



ILC BDS Magnet Progress -- Concepts

- Concepts and decisions in the last year:

- ILC decision: only one IR, with 14 mrad crossing angle
- ILC decision: push-pull arrangement of experiments \Rightarrow BDS separation into two sections, one fixed, one moveable.
- ILC decisions \Rightarrow added BNL BDS work (with less \$\$)
- Conceptual design of force-neutral anti-solenoid, integrated with final focus quad, to the level of 3D models.
- Conceptual design, model of octupole \Rightarrow helps collimation

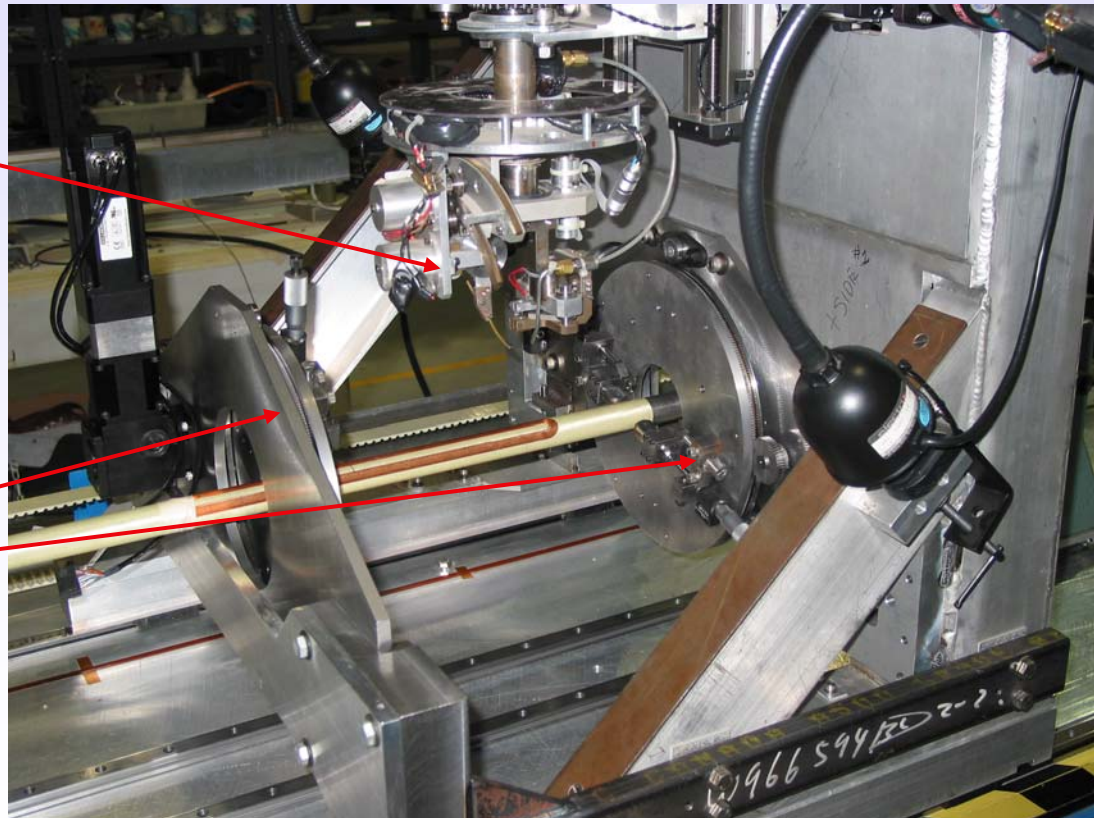


ILC BDS Magnet Progress - Hardware (1)

- Modify existing "direct wind" CAD/CAM machine to wind full-length (2.2 m) prototype final focus quad (QD0) coil.

Existing
winding
head

New:
"steady
rest" to
support
long coil

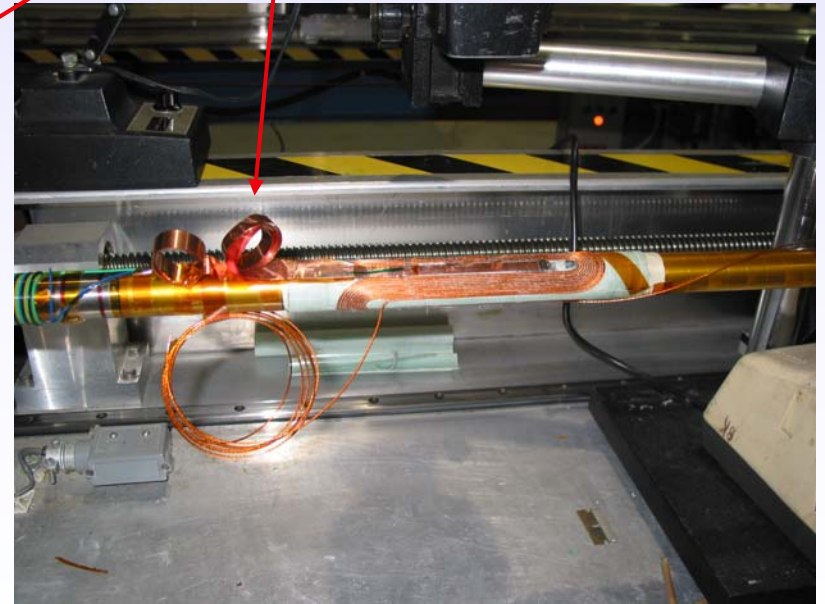
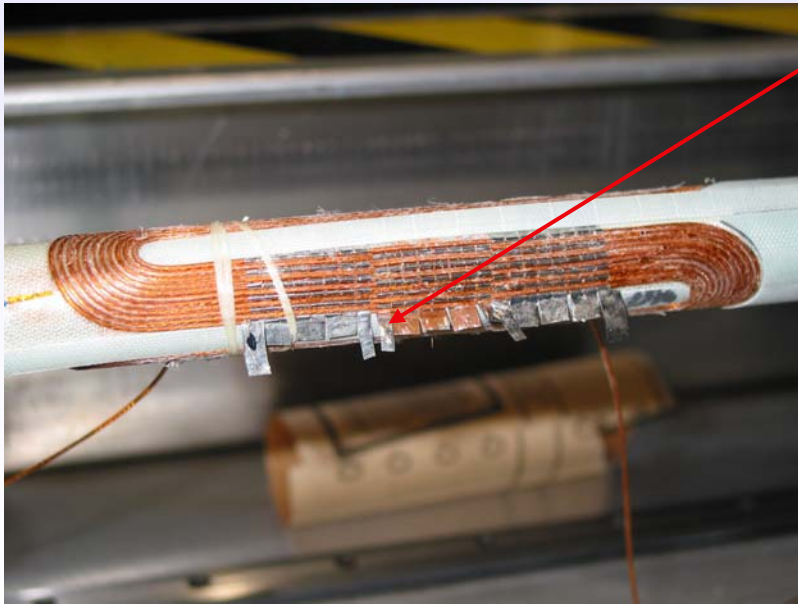


ILC BDS Magnet Progress - Hardware (2)

- Build short quad coil, instrument with heaters to measure quench initiation and propagation in “direct wind” coils, to determine tolerance for beam loss.

- Funded by BNL strategic LDRD

Heaters (2 types)



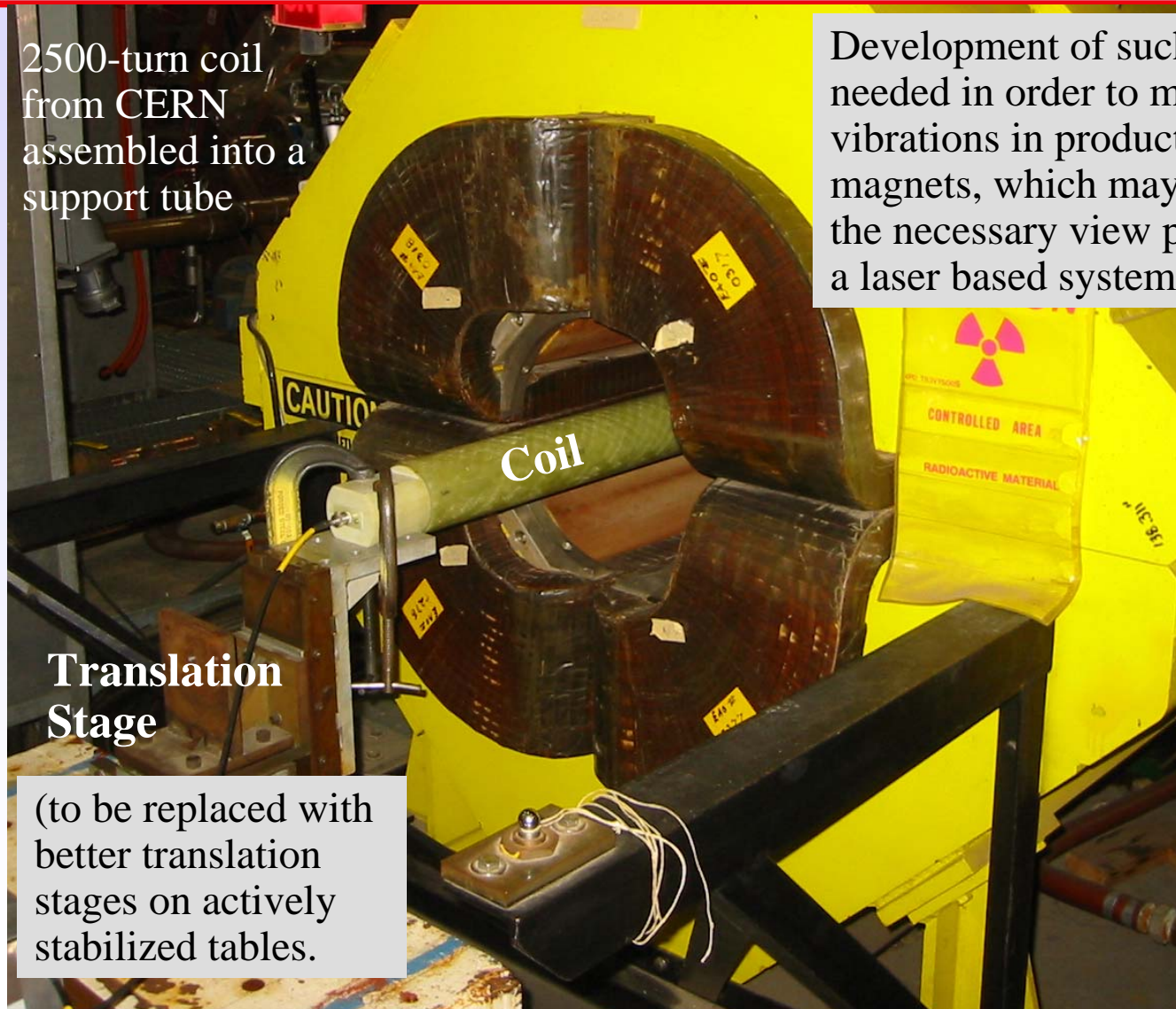
ILC BDS Progress - Magnet Vibration

- Task: Measure, control vibration of magnet to the level of a few nm (for frequencies above a few Hz).
- Progress in the last year:
 - Place new vibration stabilization tables under laser vibrometer
⇒ resolution < 1 nm for $f > 9$ Hz for measurements on a RHIC superconducting quad, with and without cryogen flow.
 - A pickup coil sensitive to motion in a magnetic field has been set up in a resistive quadrupole
⇒ resolution ~ 1 nm for $f > \text{few Hz}$ at ILC gradients.

2500-turn Pick-up Coil Setup in Room Temp. Quad

2500-turn coil
from CERN
assembled into a
support tube

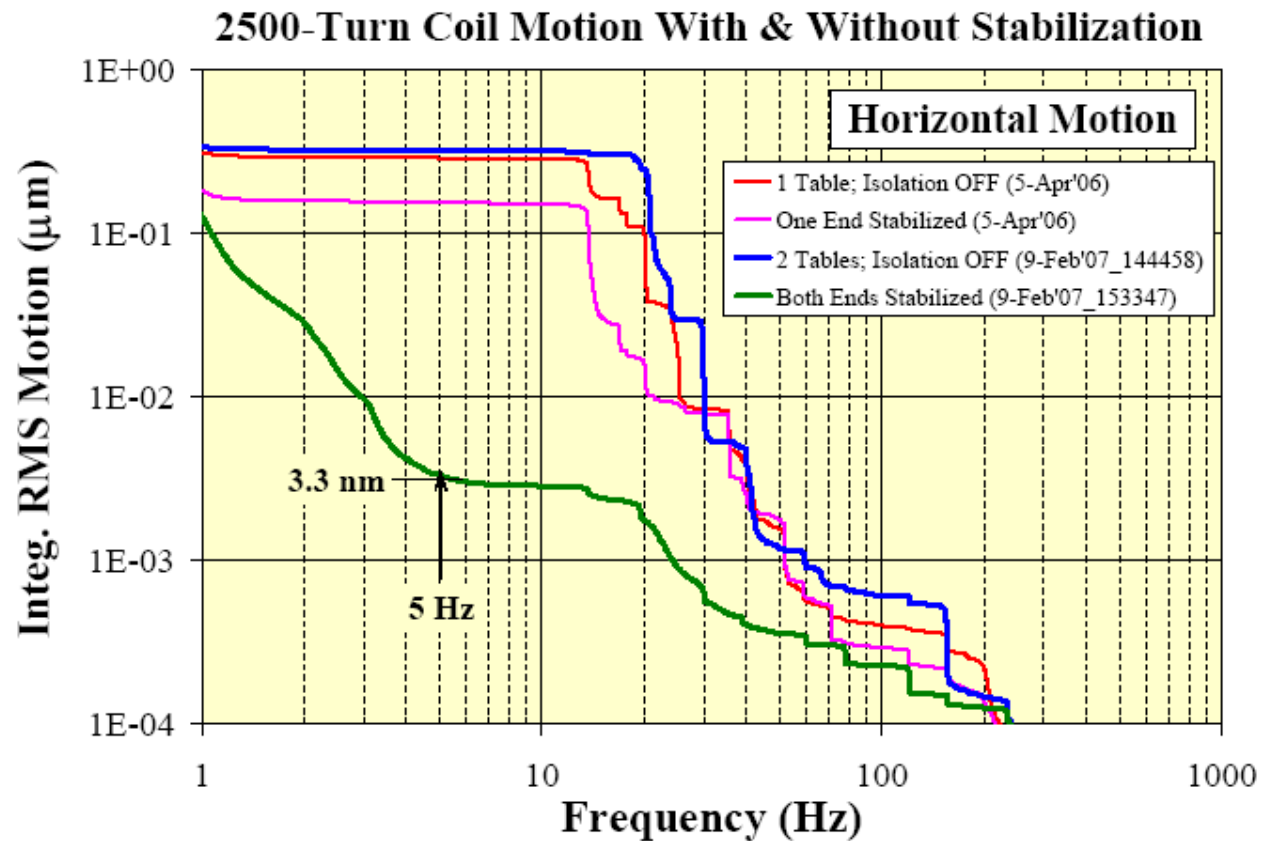
Development of such a coil is
needed in order to measure
vibrations in production
magnets, which may not have
the necessary view ports to use
a laser based system.



**Translation
Stage**

(to be replaced with
better translation
stages on actively
stabilized tables.)

Measured vibration of sensitive pickup coil in quad field



ILC BDS plans and issues

- Plans - remainder of FY07
 - Magnet system design: continue, including interaction with other ILC groups (e.g., experiments)
 - Magnet construction: make test winding(s)
 - Vibrations: additional sensitivity studies of pickup coil in quad
- Plans - longer term
 - Build mock-up of BDS system with final focus quad but dummy coils for the other magnets, including cryo, operate
 - Develop system for vibration measurement and control, use with mock-up when mock-up available
- Issues
 - Level of ILC funding insufficient to complete work prior to date for planned completion of EDR (2009)

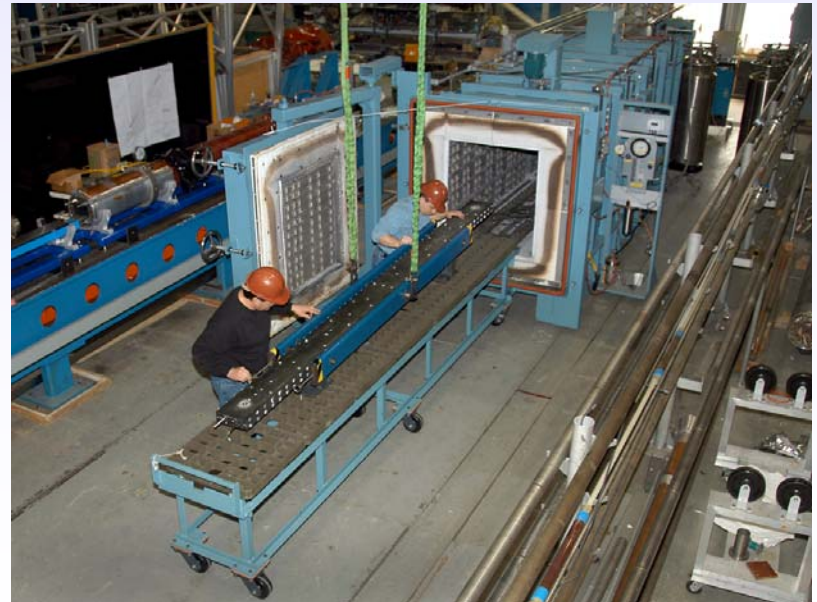
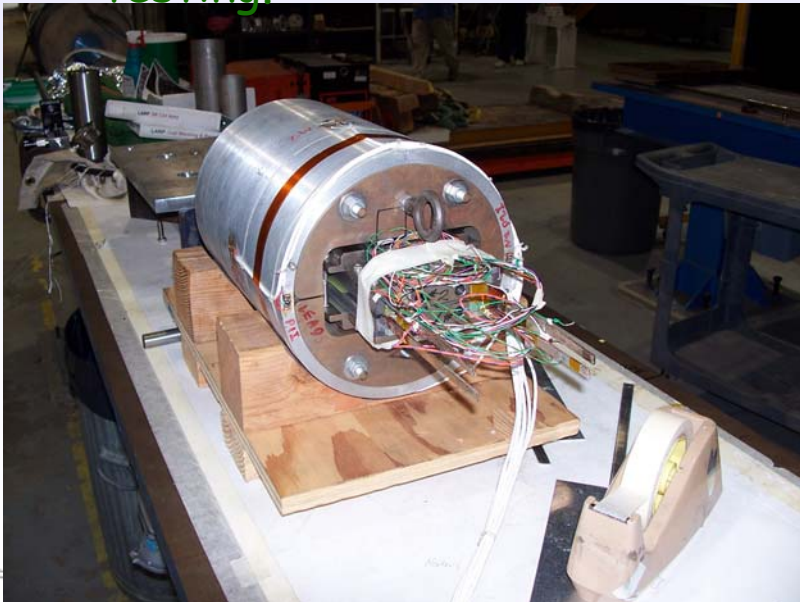
ILC Budget and Staffing

ILC

	FY06	FY07	FY08P	FY09PG
Budgets:	\$600k	\$975k	\$1,760k	\$2,877k
Labor	\$560k	\$811k	\$1,369k	\$2,337k
Material	\$40k	\$164k	\$391k	\$539k
LABOR				
Sci	1.2	1.3	1.0	1.4
Prof	0.6	1.5	1.6	2.7
Tech	0.5	0.6	2.8	4.9
Admin	0.4	0.1	0.6	0.8
FTE:	2.8	3.5	5.9	9.8

LARP Magnet & Materials R&D

- Goal: by 2009, demonstrate Nb_3Sn magnets as ok for an LHC IR upgrade. After 2009, pursue other R&D for LHC (e.g., slim quads, fast-cycling magnets, conductor development)
- BNL LARP program:
 - Magnet: Make, test racetrack coils to look for possible length effects in 4 m Nb_3Sn coils.
 - Materials: *Lead* conductor R&D and procurement, including conductor testing.



LARP Magnet & Materials R&D Accomplishments

- Magnet: Successful test of 30-cm-long version of racetrack coils \Rightarrow successful transfer of technology from LBL
- Magnet: Construction of first 4 m magnet nearly complete.
- Materials: Major accomplishment - determining threshold in superconductor size, critical current capacity for instabilities that limited magnet performance \Rightarrow "standard" material
- Materials: Managed contracts for strand and cable \Rightarrow supply of the current "standard" material available when needed for magnets.
- Materials: 130 tests of strand performed at BNL

LARP Magnet R&D

- Goals - near term
 - Magnets: successful test of first 4 m racetrack coil
 - Materials: move to a more advanced superconductor (smaller filaments \Rightarrow increased stability) when appropriate.
- Goals - longer term
 - Magnets: settle FY08 tasks (contribute to 4m quad, expand cable test effort, ...). In later years, work on other options for LHC improvements, such as "slim quadrupoles" inside the detectors, fast-cycling magnets.
 - Materials: Continue purchase, test of conductor for magnet program. Investigate new materials (e.g., Nb₃Al, HTS) with improved performance.
- Issues
 - FY08 and beyond - matching resources to R&D program.

LARP Magnet Budget and Staff

LARP (w/o C-AD)

	FY06	FY07	FY08P	FY09PG
Budgets:	\$2,515k	\$2,183k	\$2,518k	\$2,680k
Labor	\$1,605k	\$1,675k	\$1,628k	\$1,720k
Material	\$830k	\$340k	\$886k	\$923k
Sci	1.9	2.5	1.5	1.4
Prof	2.9	1.8	1.9	2.1
Tech	2.3	3.3	3.2	3.1
Admin	0.4	0.3	0.2	0.3
FTE:	7.5	7.9	6.8	6.9

Superconducting Materials R&D

- Overview: Work closely with vendors and magnet builders to improve, characterize materials, focusing on HEP applications - NbTi (no work underway now), Nb₃Sn (primarily LARP now), High Temperature Superconductor (both cable and tape forms).
- Examples of recent work:
 - Development of standard method (among BNL, Fermilab, LBL) of testing strand.
 - Understanding relation between stability, filament size, and current-carrying capacity (J_c). This led to specifications for a standard Nb₃Sn for LARP.
- Goals:
 - Near-term: support LARP and new materials
 - Longer-range: upgrade cable test facility (see next slide)
- Issues: funding to support, upgrade cryo test facility

Superconducting Materials - Upgrade Cable Test Facility

- Testing superconducting cables planned for use in magnets is a valuable QA check. Testing also offers a chance to optimize cabling parameters (especially the keystone angle) separately from magnet fabrication issues.
- Have requested funding over two years to upgrade our cable test facility to test at the higher background fields appropriate to Nb_3Sn (compared to NbTi). The proposal makes use of our existing 10 T magnet to minimize the cost.
- Proposal for funds in addition to the core program:
 - FY08R additional \$236k (not included in budget table)
 - FY09 \$454k (included in budget table)

Superconducting Materials Budget and Staffing

Superconducting Materials R&D

	FY06	FY07	FY08P	FY09R
Budgets:	\$404k	\$700k	\$765k	\$1,467k
Labor	\$371k	\$513k	\$718k	\$1,085k
Material	\$33k	\$187k	\$47k	\$381k
LABOR				
Sci	0.7	0.7	0.3	0.9
Prof	0.1	0.4	0.6	0.9
Tech	0.8	1.0	1.8	2.2
Admin	0.0	0.1	0.5	0.4
FTE:	1.6	2.2	3.2	4.5

Accelerator Magnet R&D

- Overview: Superconducting magnet R&D for accelerators.
- Recent accomplishments: successful test of “react and wind” Nb₃Sn 10 T common coil dipole (March 06)
 - Cable was wound after reaction - i.e., in brittle state.
 - This magnet could be used in an upgrade of the cable test facility.
- Not funded in FY07; funded in FY08
- Goals - New direction - HTS for accelerator magnets
 - HTS coils to replace coils in existing resistive magnet, coils from industry (CRADA).
 - Study use of HTS, using as example ILC extraction line magnets.
- Issue: slow progress due to lack of funding this FY.

Accelerator Magnet R&D Budget and Staffing

Magnet R&D

	FY06	FY07	FY08P	FY09R
Budgets:	\$400k	\$0	\$388k	\$417k
Labor	\$386k	\$0	\$334k	\$351k
Material	\$32k	\$0	\$54k	\$66k
LABOR				
Sci	0.3	0.0	0.1	0.2
Prof	0.6	0.0	0.3	0.3
Tech	0.7	0.0	0.7	0.6
Admin	0.2	0.0	0.3	0.3
FTE:	1.9	0.0	1.5	1.5

Fast-cycling Magnet R&D

- Overview:

- New proposal - funding FY08 \$225k, FY09 \$305k funding not in FY08P)
- There are several examples of fast-cycling accelerators around the world: **J-PARC** booster ring, **SNS** (alternate design, not used), **GSI FAIR** (two rings of superconducting magnets), **PS2** (CERN PS upgrade, possibly with superconducting magnets) \Rightarrow motivation for US HEP to put modest development into this type of magnet.
- Propose to use tooling developed for a successful model superconducting magnet built for **GSI** several years ago to make another model that will advance our understanding of magnet eddy current heating and field quality. The use of existing tooling minimizes the cost.
- The ramp rate of the **GSI** magnet is 4 T/s, about 50x faster than the **RHIC** ramp rate.

Internal Reviews

- Review of Magnet Division as a whole - June, 2006
 - Organized by BNL ALD (Sam Aronson)
 - Included members of BSA Trustees Science and Engineering Committee and BNL staff
 - Conclusions:
 - Future work will be R&D, few-of-a-kind \Rightarrow reduce footprint
 - Size of staff \sim ok, but R&D \Rightarrow different mix of skills
- LARP and ILC:
 - Internal reviews
 - Collaboration meetings
 - DOE

Summary Budget and Staffing

HEP TOTAL

	FY06	FY07	FY08P	FY09
FTE's	15.2	16.8	17.2	25.0
Budget	\$4,668k	\$4,339k	\$6,013k	\$8,061k

Conclusions and Issues

- Conclusions:
 - Superconducting Magnet Division work for HEP is aligned with national goals: ILC, LARP/LHC.
 - Collaborative work
 - Distinctive contributions
 - C-AD projects and Work for Others \Rightarrow much larger range of skills than would be possible with HEP funds alone.
- Issues:
 - Efficient operation of cryo test facility